

BUREAU OF ENVIRONMENTAL HEALTH Emergency Response/Indoor Air Quality Program

Methods for Increasing Comfort in Non-Air-Conditioned Schools

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The Emergency Response/Indoor Air Quality (ER/IAQ) Program routinely receives inquiries concerning the problem of high temperatures in schools and other buildings during unseasonably hot, humid weather. These concerns are usually raised in late spring/early summer or late summer/early fall. School officials should treat hot, humid weather in the same manner as foul weather (e.g., snow) when making decisions concerning student and staff safety. In an effort to aid school officials in judging the effects of heat, this document compiles information concerning indoor air quality in non-air-conditioned school buildings. Please note that excessively hot weather can produce conditions of heat cramps, heat exhaustions and in extreme conditions heat stroke, which is a medical emergency (US EPA, 2006). All of these conditions can occur in individuals who are active in hot weather.

A large number of schools do not have mechanical air-conditioning building-wide, but rather rely on open windows to provide heat relief during hot weather. The ER/IAQ Program recommends that indoor air temperatures be maintained in a range of 70° F to 78° F in order to provide for the comfort of building occupants. Frequently, the upper limit of this comfort range

is exceeded in warm weather, since control of temperature in non-air-conditioned buildings is difficult. Relying on openable windows and cross ventilation in hot weather will at best, render indoor temperature to a level equal to outdoor temperature. The heat load carried by building materials exposed to direct sunlight further increases the internal temperature of buildings. Building components, such as single-paned window glass, insulated window frames, skylights and exterior brick, can radiate heat into the interior, resulting in increased indoor temperatures over the course of a school/work day. Frequently, older school buildings are not designed to prevent transfer of heat from solar heated exterior walls and windows to interior occupied space. Therefore, many buildings (particularly schools) are not equipped to provide for the comfort of building occupants during hot/humid weather during summer months.

What Is Extreme Heat?

Temperatures that hover 10 degrees or more above the average high temperature for the region and last for several weeks are defined as extreme heat (CDC, 2006). Humid or muggy conditions, occur when damp air is near the ground. Droughts occur when a long period passes without substantial rainfall. A heat wave combined with a drought can be a very dangerous situation (CDC, 2006).

Methods That Can Be Used To Increase Thermal Comfort in a Building

Hydration

Replacement of fluids is of utmost importance during hot weather. Building occupants should be encouraged to drink water regularly during school/business hours (consultation concerning the appropriate amount of hydration with the school medical staff is encouraged). ***Please note*** that some building occupants may be particularly susceptible to heat related problems. Individuals who are **at greater risk** include:

- Infants and children up to four years of age;
- People over 65 years of age;
- Individuals who are overweight;
- Individuals who overexert due to exercise; and
- Individuals who are physically ill, especially those with heart disease or high blood pressure, or who take certain medications, such as for depression, insomnia or poor circulation (CDC, 2006).

These individuals should be monitored, and accommodations should be made to address hot weather concerns for these individuals beyond hydration.

Heat Gain Reduction/Waste Heat Elimination

An additional strategy used to reduce heat in a building may include employing methods to reduce heat gain transmitted through single pane, metal window frame systems. Use of opaque, heat absorbing curtains to block heat transmission should be considered. Dedicated local exhaust

ventilation can be used to direct waste heat produced by equipment to the outdoors. If no exhaust ventilation exists, minimize the use of fossil-fuel and electric-powered equipment where feasible (e.g., cooking equipment, photocopiers, computers, pottery kilns, fluorescent lights).

Increased Airflow

A variety of methods can be used to increase comfort indoors during hot weather, however, caution must be used. “Electric fans may provide comfort, but **when the temperature is in the high 90s, fans will not prevent heat-related illness**” (CDC, 2006). Therefore, mechanical fans can be used to supplement a variety of other actions that can be used to increase the comfort of building occupants; however, fans should not be used solely to increase comfort.

The method employed to increase airflow is dependent on the type of building. Buildings built prior to 1940 were configured in a manner that utilizes cross-ventilation to provide comfort for building occupants. These buildings frequently are equipped with windows on opposing exterior walls. In addition, these buildings will have a hinged window located above the hallway door. This hinged window, known as a transom, enables occupants to close the hallway door while maintaining a pathway for air to flow. This design allows for airflow to enter an open window, pass through a classroom, pass through the open transom, enter the hallway, pass through the opposing open classroom hallway, into the opposing classroom and exit the building on the leeward side of the building (Figure 1). With all windows and transoms open, airflow can be maintained in a building regardless of the direction of the wind. This system fails if the windows or transoms are closed. These buildings generally have a long pole with a hook used to open the hoop latch that locks the transom in each room (Figure 2). To aid in the draw of fresh outdoor air in warm weather, portable fans can be placed directing air out windows on the leeward side of

the building. Fans positioned in this manner will serve to increase the draw of outdoor air across a school floor without interfering with the natural internal airflow pattern of a building. If no transoms exist, hallway doors should be opened to create airflow.

Buildings constructed after 1940 are frequently equipped with unit ventilator (univent) systems (Figure 3). The interior wall will typically be equipped with a ducted exhaust ventilation system that is connected to a rooftop vent motor. This system can provide airflow in a building independent of outdoor wind direction. With this type of ventilation system, univents should be operating during school hours with the fresh air damper open 100%. In essence, this configuration converts the univent into a large fan system. The operation of the exhaust vent system will serve to create airflow and remove heat and water vapor from classrooms. Many schools deactivate the univents and exhaust vents in the mistaken belief that these systems only provide heat during winter months. Operating these systems during hot weather will *supplement* the use of open windows. If sections of the ventilation system do not operate, the placement of fans to exhaust air from the leeward side of a building with hallway doors open may be employed.

Removal of Water Vapor

Internal sources of water vapor (e.g., food services and restrooms) can serve as sources of moisture that can increase local relative humidity levels, especially in hot, humid weather. Kitchens frequently are equipped with local exhaust ventilation for ovens and dishwashing equipment. Operation of these systems during hot weather is essential to remove both heat and moisture from the kitchen and cafeteria. Restrooms are also equipped with local exhaust ventilation that can reduce moisture load in occupied areas. Locker rooms with showers also

frequently have local exhaust ventilation. The operation of local exhaust ventilation to remove water vapor can be used to improve comfort in hot weather.

Temperature Guidelines

The ER/IAQ Program using a guideline of 70° F to 78° F as a comfort range for temperature inside buildings. If indoor temperatures exceed 78° F, methods to increase the thermal comfort of building occupants may be employed. Several guidelines exist concerning heat stress and discomfort in hot weather.

Heat Index

Temperature comfort is also dependent on the perception of heat by an individual, which can be expressed as the heat index. The body cools by producing sweat to reduce internal body heat through the skin. When relative humidity increases, the ability of moisture to evaporate from skin decreases, therefore preventing heat loss and increasing an individual's discomfort. The heat index is a description of how hot a person feels as temperature in combination with relative humidity rises. The following chart produced by the National Weather Service shows the heat index that corresponds to the actual air temperature and relative humidity.

Table 1: Heat Index Table

Temperature (F) versus Relative Humidity (%)						
°F	90%	80%	70%	60%	50%	40%
80	85	84	82	81	80	79
85	101	96	92	90	86	84
90	121	113	105	99	94	90
95		133	122	113	105	98
100			142	129	118	109
105				148	133	121
110						135

HI	Possible Heat Disorder:
80°F - 90°F	Fatigue possible with prolonged exposure and physical activity.
90°F - 105°F	Sunstroke, heat cramps and heat exhaustion possible.
105°F - 130°F	Sunstroke, heat cramps, and heat exhaustion likely, and heat stroke possible.
130°F or greater	Heat stroke highly likely with continued exposure.

This chart is based upon shady, light wind conditions. **Exposure to direct sunlight can increase the HI by up to 15°F.** Due to the nature of the heat index calculation, the values in the tables below have an error +/- 1.3F (NWS, 2005)

Using this chart as a guide, when the heat index indoors **exceeds 88°F**, methods to increase the thermal comfort of building occupants should be employed.

Thermal Comfort Guidelines

Several conditions can affect the comfort level in a building during warm weather.

1. Individuals in warm weather adapt to the temperature of the environment over time.
Where outdoor temperatures fluctuate between 10° F to 20° F, individuals become uncomfortable for a time until their body acclimates to the increased temperature.

2. The amount of heat perceived by the individual is related to the activity of the individual.
The more physical the activity, the greater the need of cooling.
3. Increased relative humidity increases discomfort with increasing temperature.
4. Radiant sources of heat can serve to increase temperature inside a building.
Photocopiers, computer monitors, televisions, fax machines, ceiling lights and laser jet printers are all sources of waste heat that, if not vented, can add to the heat load inside a building.
5. Clothing provides insulation to the body. The thicker the clothing, the greater the insulation and therefore the greater the discomfort of the individual.

The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) produced guidelines to maintain thermal comfort in buildings, including hot weather. As comfort levels decrease with increased temperature coupled with increased relative humidity, the ASHRAE thermal guidelines provide a comfort range that will provide for comfort of 90% of a building population, with 10% of that population expressing dissatisfaction. An individual dressed in typical summer clothing during light, primarily sedentary activity would be comfortable in a temperature range of 72.5° F to 78.5° F at a relative humidity of 60 %; or in a temperature range of 73.5° F to 82° F with a relative humidity of 30% (ASHRAE, 1992). These temperatures coupled with relative humidity are the ranges to assess whether 90% of a building population will be comfortable.

Occupational Guideline for Workers

Thermal stress guidelines for workers provide guidance that may be of some assistance. In an environment where the individual working hour consisting of 25% work and 75% rest, an

unacclimated individual conducting light work (e.g., sitting or standing to control a machine, performing light hand or arm work) would have a threshold limit value of *roughly 88° F* (ACGIH, 1999). This temperature assumes that the individual is a healthy adult at a workplace. The American Conference of Governmental Industrial Hygienists (ACGIH) does not provide guidelines for activities that are defined as resting (e.g., sitting quietly or sitting with moderate arm movements) or for the elderly, non-adults or individuals with compromised health.

Conclusion

Precautions should be taken to increase the comfort of individuals in non-air-conditioned buildings in hot, humid weather, particularly individuals with compromised health. Information concerning recognition of heat related symptoms and treatment can be found in the Summer Heat Precautions Fact sheet posted at the MDPH's website:

<http://www.mass.gov/dph/seasonal/sumheat.htm>. For further information on methods that can be used to reduce heat in un-air-conditioned building and other indoor air quality related issues, contact the Emergency Response/Indoor Air Quality Program at (617) 624-5757.

References

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Figure 1: Cross Ventilation in a Building Using Open Windows and Transoms

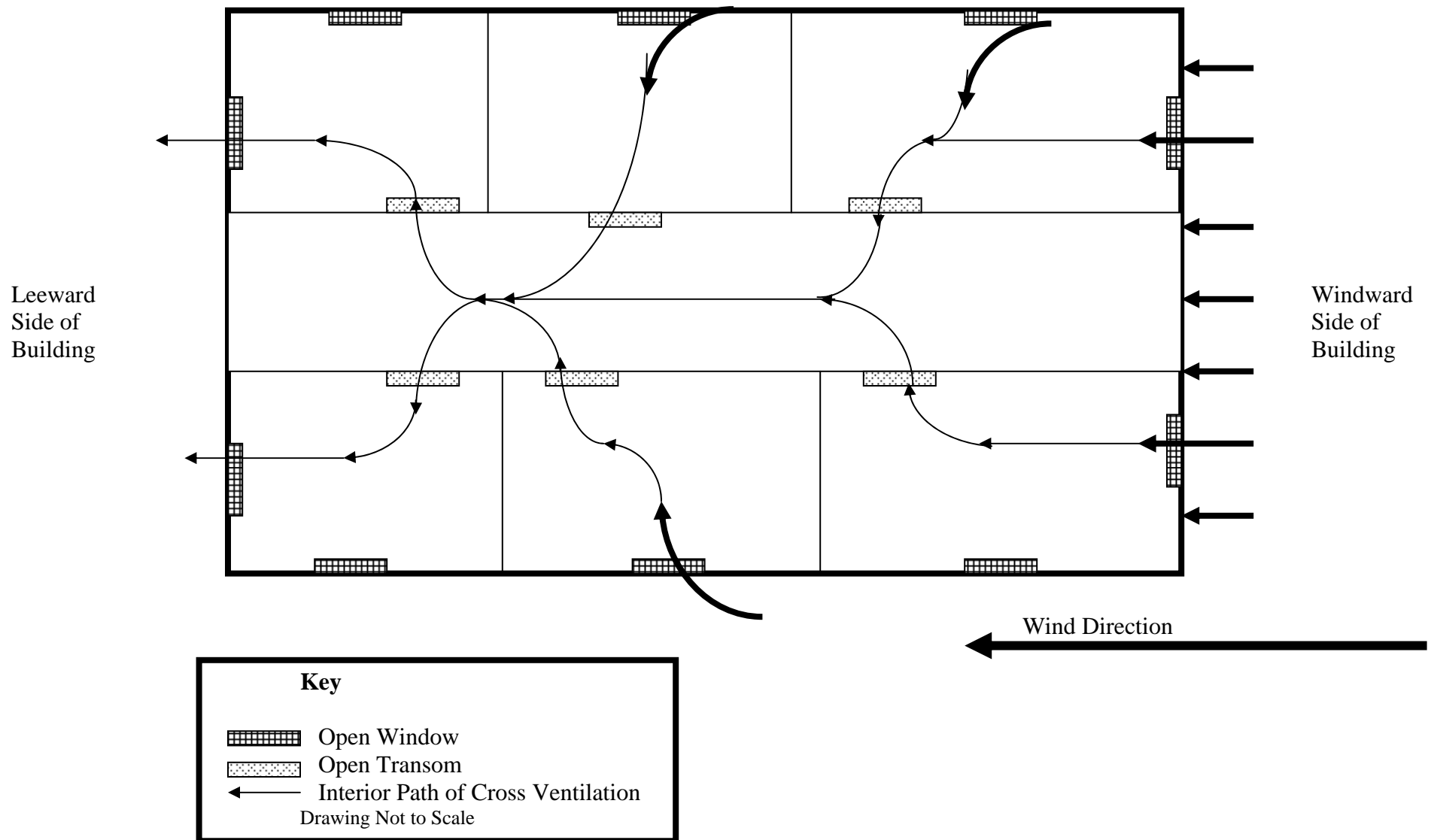


Figure 2: Inhibition of Cross Ventilation in a Building with Several Windows and Transoms Closed

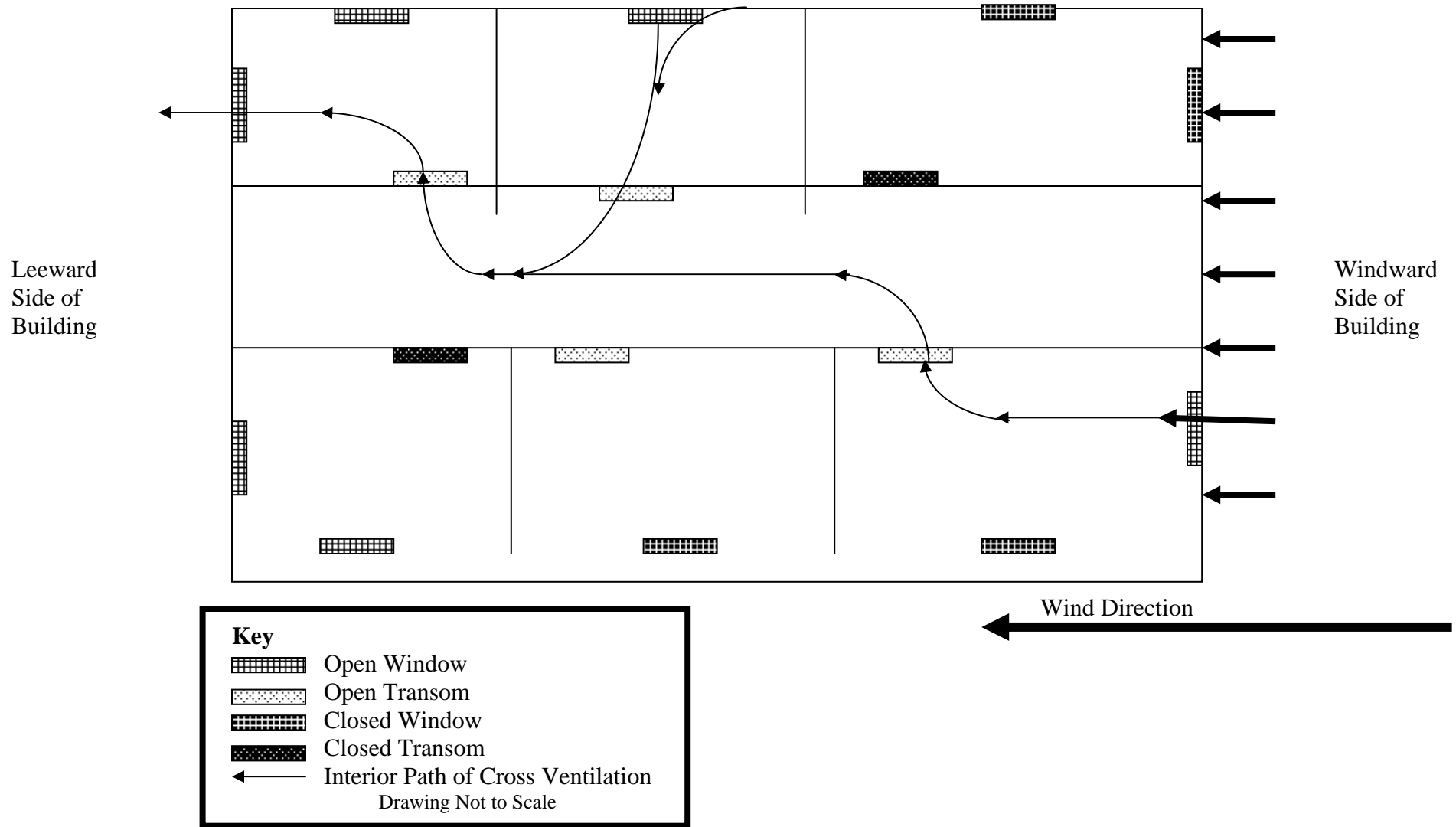


Figure 3 : Unit Ventilator (Univent)

